STAT

Internal Combustion Ship Engines

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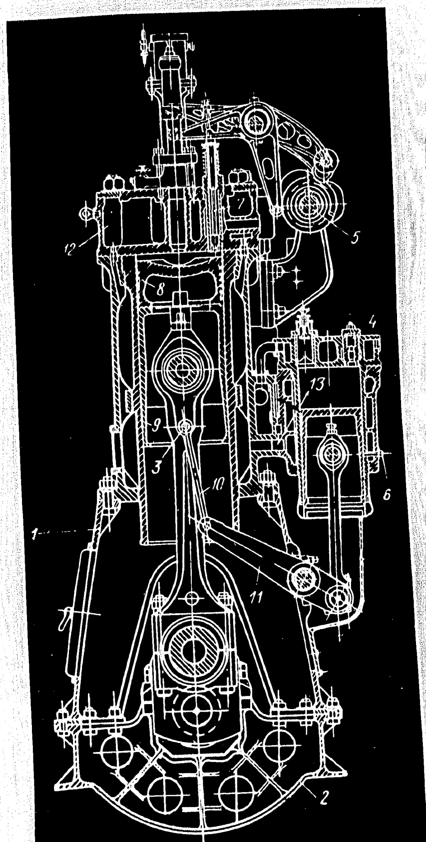
SECTION 29. DESIGNS OF MARINE COMPRESSOR DIESELS

There is at the present time a relatively small number of ships powered by compressor Diesels. The type of Diesel to be found aboard such ships is almost invariably the four-cylinder unit produced at the Kolomna Plant during the period from 1911 to 1916. The bulk of the engines used on the passenger ship line Gor'kiy-Astrakhan' are of the 25 Oktyabr' type or of types, very similar to it, employed on old refrigerator, freight-passenger vessels and tugboats.

Passenger vessel engines of the 25 Oktyabr' type, installed aboard ships in pairs, are of the six cylinder, four stroke compressor Diesel type which develop an effective power of 600 horsepower at a speed of 240 rpm. The diameter of each of the cylinders is 410 millimeters, while the piston stroke is 560 millimeters. A cross section of such an engine is shown in Figure 158.

The engine is provided with a common casing (1) in the form of a crankcase resting on the bedplate (2) with a semi-circular bottom. The intake and exhaust valves are fitted with a device that enables them to open pneumatically for reversing. This device is discussed in Section 20 (see Figure 114). In order to reverse it is necessary to shift the circular cams of the forward and reverse run, these cams being mounted on special intermediate sleeves which are located on the camshaft (5). The camshaft, again, is lodged in the bearings of the brackets which are coupled with the cylinders. An injector is also to be found in the cylinder head with a lamellated nozzle along with a starting valve (7), as



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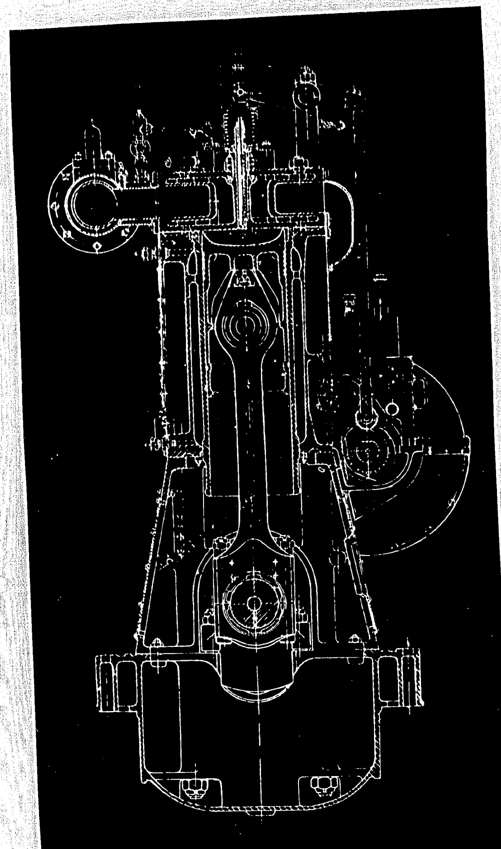

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Figure 158

Figure 159

shown in the cross section.

The engine piston which is not cooled is provided with a separate head (8) connected to the jacket (9) by pins. The connecting rod is of customary design. The crankshaft has recesses bored in it and is provided with diagonal channels for the feeding of oil under pressure.

The engine has a three stage air compressor. Each cylinder piston of this compressor is actuated by means of connecting rods (10) and a rocking lever (11) from the piston rod (3) of the adjoining operating cylinder. Two piston pumps which feed cooling water are similarly actuated by connecting rods and rocking levers. The cooling water first enters the area of the cylinders outside of the jackets and from there it is introduced into the cooling spaces (12) of the cylinder head. The area of the compressor cylinders beyond the jackets is connected by a duct (13) with the outer area of the operating cylinders. Openings are provided for the purpose of cleaning the surfaces that are being cooled.

In addition to the cooling of the housing the exhaust valve head is also cooled through the hollow rod into which is inserted a tube for the feeding of water.

The lubrication of the assembly is effected by circulation. The working cylinders of the engine and of the compressor have forced lubrication. For the purpose of water cooling, should they become heated, the bedplate bearings are provided with recesses. The control post of the engine is situated on the level of the camshaft. For purposes of starting, the cylinders are divided into two groups. At the outset, when started, both groups function on compressed air. Then one group of three cylinders is switched to fuel while the other group continues to function by compressed air. Only when continuous sparking sets in in the first group of cylinders is the second group also shifted to fuel oil.

The engines under consideration proved dependable and durable in service. However, there are a number of shortcomings as regards the spraying of the compressed air, as has already been pointed out in Section 14. Compressor Diesels are always less economical and heavier than those without compressors. For this reason, it may prove worthwhile to modernize the Diesel by resorting to spraying by means of pumps in those instances where the compressor Diesel is in good mechanical condition.

The conversion of a compressor Diesel to a non-compressor type entails first of all the replacement of its fuel apparatus. In this case it is to the greatest advantage to replace the old fuel pumps with new ones which are provided with gas plungers. The injectors are, as a rule, replaced with sealed type injectors that are most adaptable to the Diesels of the non-compressor type. High powered compressors which, owing to their capacity, have become superfluous, should be removed and other compressors of a much lower capacity, and powered by the electric motor, should be installed for the purpose of pumping air into the starting cylinders. The adoption of a fuelling mechanism with a gas plunger is apt to lead to considerable simplification of the Diesel control post. Such a conversion of compressor Diesels into non-compressor units has been carried out successfully on a number of Diesel-propelled ships of our ocean-going fleet and the results proved to be of a positive nature.

SECTION 30. TYPES OF SLOW SPEED NON-COMPRESSOR DIESELS

Both the main and auxiliary engines of our river fleet employ a series of four and two stroke, non compressor Diesels of the slow speed type. The vast bulk of these engines is produced in our own domestic plants. As a rule, the effective output of engines of this type does not exceed 600 horsepower (there are only a few engines developing 700 horsepower). All the higher powered engines are of the four stroke type. The two stroke engines do not exceed 210 effective horsepower.

A major portion of the four stroke, non-compressor Diesels to be found on river craft comes from the following plants: the Sormovo, Kolomna and Dvigatel' Revolyutsii Plant. These are all engines of the same design. The six cylinder engines of the following makes are exclusively employed as main engines:

6 ChR $\frac{29}{43}$ (plant symbol 6-BK-43) produced by the Sormovo Plant;

6 ChR $\frac{34.5}{50}$ (plant symbol 50 GRS-6) of the Kolomna Plant, and the DRS-400 of the Dvigatel' Revolyutsii Plant

6 ChR $\frac{42.5}{60}$ (plant symbol 60-GRS-6) produced by the Kolomna Plant.

The six xylinder engines of the 6 ChR make develop an effective output of 280 to 350 horsepower depending on the number

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of revolutions which may vary from 280 to 350 rpm. Engines of this type are installed on a number of passenger ships, on a series of power driven barges and other river craft. Similar engines, only with a different number of cylinders (3 and 4) of the non reversing type are frequently encountered among the electric plants of repair docks.

The transverse section of the 6 ChR $\frac{29}{43}$ engine appears in Figure 159. The diameter of the engine cylinders is 29 centimeters while the piston strokes are 43 centimeters. All the principal immovable parts are of cast iron. The bedplate, crankcase and cylinder banks are coupled by means of anchor bolts. The bedplate is a solid casting. That is true also of the housings. The engine bed bearing bushes are of steel with babitt linings. Three cylinders are cast into one bank. The cylinder liners are detachable and of cast iron. Each of the cylinders has an individual head. Lodged in the cylinder head are the injector intake, exhaust starting, and safety valves.

The crankshaft of the engine is seamless forged. The connecting rod is of steel, of circular section, bored, with a detachable lower head and lined with babitt. A bronze bushing is pressed into the upper head of the connecting rod, and forms a bearing. The piston is of cast iron, without cooling. It is provided with five sealing rings and two oil scrapers.

The camshaft is actuated by the crankshaft by cylindrical gears placed on the stern side of the engine. It is here also that we find the centrifugal governor which is connected with the crankshaft by means of a spur and bevel gear.

There is a separate fuel pump for each of the cylinders, actuated by the cam plates found on the camshaft. Its operation has already been discussed in Section 17. The speed of the engine can be regulated within the range of 90 and 370 rpm. The open type injector has also been analyzed in Section 16 (see Figure 87). The engine is equipped with injection pumps, and the fuel is fed under a pressure of 300 atmosphere. M-3 motor oil is used as fuel. The rated consumption of the fuel is 180 grams per horsepower-hour (with a 5 percent allowance).

All the working parts of the engine are lubricated through circulation, whereas the cylinders are lubricated by injection. The gear driven oil pump (see Figure 145) is actuated from the crankshaft through the intermediary of spur gears. A composite mesh filter and oil cooler are set into the lubricating system. The pressure of the oil in the manifold is from 0.6 to 1.0 atmospheres. The motor oil best suited for engine lubrication is the M or L motor oil. The rated maximum consumption rate of the oil is three grams per horsepower per hour.

The gear driven pump, actuated by the crank on the forward side of the crankshaft, under a pressure of 0.2 to 0.3 atmospheres, is employed to feed cooling water. The cooling system is of a circulatory type. In addition to the cooling water pump, the engine is also provided with a bilge pump of an identical type. The maximum consumption of cooling water at a variable temperature of 20 degrees Centigrade is 26 litres per 1 horsepower per hour.

The engine is started by means of compressed air under a pressure of 30 atmospheres. The minimum starting air pressure is 15 atmospheres. The engine is reversed by shifting the camshaft. The reversing mechanism has already been described in the foregoing (See Figure 116). The control post is situated on the forward side of the engine. At the control post is to be found the starting lever, the hand wheel regulating the fuel supply and the reversing flywheel which is manually operated.

The 6 ChR $\frac{34.5}{50}$ engines have a very similar design. They are employed as main engines on a great many freight-passenger river craft, on Diesel propelled freighters and Diesel propelled tugboats of the Astrakhan roadsted. These Diesels are also six cylinder units developing an effective power of 400 horsepower at a rate of 240 rpm. The cylinder diameter is 34.5 centimeters while the piston stroke is 50 centimeters.

A cross section of the 6 ChR $\frac{34.5}{50}$ appears in Figure 160. In contrast to the previous 400 horsepower engine, these have a crankcase made up of cast iron uprights with intervening steel plates. The bushings of the bedplate bearings are of cast iron. The connecting rod top and bearing is composed of a steel bushing, lined with babbitt. The fuel pumps are of identical designs as those of the preceding engines. The centrifugal governor which is driven by the camshaft, functions as a limiting control, although it is possible to vary the rate of speed from 100 to 250 rpm by using the manual control. The open injector has five bores, 0.5 millimeters in diameter. The fuel oil is forced under a pressure of 250 to 300 atmospheres. M-3 motor oil may be used for fuel. The rated fuel consumption is 185 grams per effective horsepower hour.

Lubricating oil for the moving parts is applied by circulation; that for the cylinders by injection. The oil pump is gear driven and of the same design as that of the 6 ChR $\frac{29}{43}$. Type T of oil should be employed for the lubrication of the engine. The guaranteed consumption of this oil is 5.5 grams per horsepower hour. The pressure in the oil manifold while the engine is in operation should be maintained at 1.0 to 2.0 atmospheres.

This engine has a cooling water circulating system. Two gear driven pumps are mounted on the engine for the purpose of feeding water. There is also a bilge pump. The cooling water consumption is 23 litres per 1 horsepower hour and the temperature difference between the intake and discharge water is 30 degrees Centigrade.

Compressed air at 30 atmospheres is applied for the starting of the engine. Minimum pressure of the starting air is 15 atmospheres. A two-stage compressor on the forward side of the engine serves to feed compressed air into the starting cylinders. This compressor is set in motion by the additional crank of the crankshaft. Much the same type of mechanism as distinguishes the 6 ChR $\frac{29}{43}$ is employed for reversing, except that in this instance an air and oil servomotor is employed, as shown in Figure 117.

Special slotted openings in the cylinder heads are provided for the insertion of indicators. A lever device, which can be seen

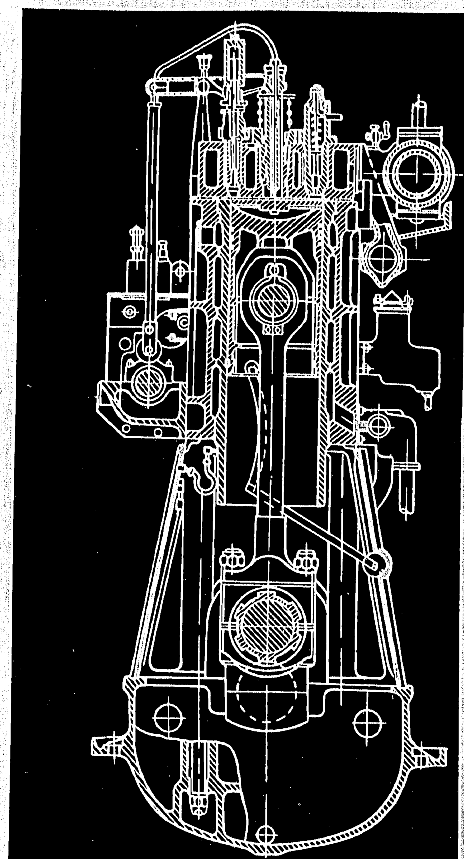

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Figure 160

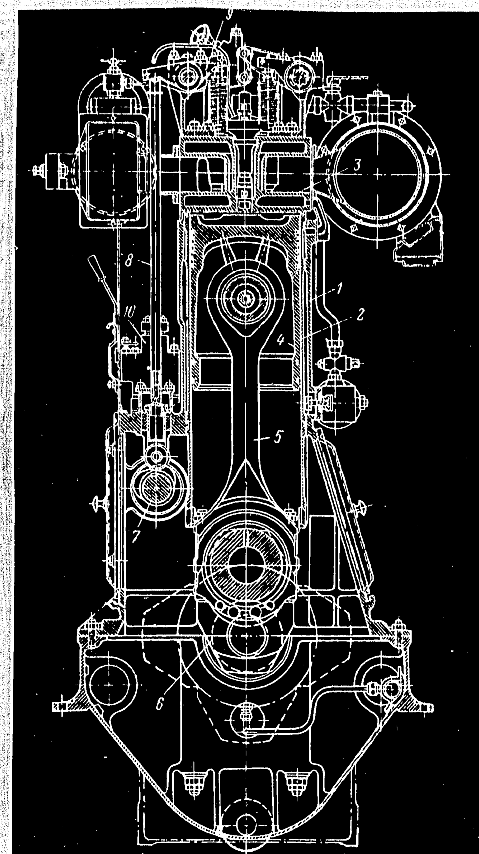

Figure 161

on the cross section of the engine, is employed to actuate the indicators.

The 6 ChR $\frac{42.5}{60}$ type engines which develop an effective output of 600 horsepower at 187 rpm, are of the identical design except for the dimensions. The engine has six cylinders with a diameter of 42.5 centimeters and a 60 centimeter piston stroke. Notwithstanding the fact that the output per cylinder is 100 horsepower, the pistons are not air or oil cooled, so that it was possible to preserve a simple engine design. 6 ChR $\frac{42.5}{60}$ engines are installed aboard the tugboats of the Volgotanker steamship line.

The three types of engines considered above proved reliable over an extended period of service. The use of open injectors must be regarded as the principal shortcoming of these engines. Moreover, they are comparatively heavy. Thus, for instance, in the case of the 6 ChR $\frac{29}{43}$ type Diesel, the weight comes to 50 kilograms per horsepower for the 6 ChR $\frac{42.5}{60}$. It must be conceded that from a modern point of view, this weight is excessive.

On the tugboats and freighters now under construction by the Krasnoye Sormovo Plant 18-D type engines are being installed, these engines being produced by the Kolomna Plant. An engine of this type is shown in cross section in Figure 161. The 18-D is a six cylinder, four stroke, non compressor, reversing type Diesel developing 300 horsepower. The cylinder diameter is 300 centimeters and the piston stroke is 38 centimeters. The engine rate of speed is 300 rpm which gives it a mean piston speed of

3.8 meters per second. [Engines with a rate of speed of 400 rpm and developing an output of 400 horsepower are also being produced.]

The cylinders of this engine are seated on a single bank (1) into which are fitted the liners (2). Two intake and two exhaust valves are mounted in the head of each of the cylinders (3). The pistons (4) are of cast iron and each have five packing rings and three oil scrapers. The connecting rod (5) is of one piece with the upper part of the big end bearing. The crankshaft (6) is seamless forged. The camshaft (7) is driven by the crankshaft with the aid of a gear drive. The valves are actuated by the cam plates and rollers through push rods (8) and levers (9). The fuel pumps (10) are placed above the camshaft.

The fuel for the engine is sprayed by a pump which delivers it to closed injectors under pressure of 180 to 220 atmospheres the instant the needle is open. In the fuel pumps proper the pressure develops to as high as 500 to 550 atmospheres. The fuel is delivered to the fuel pumps with the aid of auxiliary pumps under a pressure of 0.9 atmospheres. To reverse, the camshaft is shifted by means of a pneumatic servomotor.

Among the new additions in the fleet the one engine of foreign make that deserves special mention is the Diesel manufactured by the firm of Klockner, Humboldt and Deitz. To take one example of this type of Diesel let us examine the 450 horsepower 400 rpm six cylinder engine. The diameter of this engine's cylinders is 320 millimeters, and the piston stroke is 450 millimeters.

A cross section of this engine is shown in Figure 162. One of its special features is its ability to function not only on liquid fuel but also on generator gas with an admixture of a liquid fuel. The jackets of all the six cylinders and the crank-case type housing constitute a single block iron casting. The bedplate (1) is also of cast iron and is secured to the base formed out of elements of the bilge assembly. The casing (2) is provided with rectangular hatches which are equipped with covers (3). The object of these is to facilitate access to the moving parts and to the housing bearings. The dismountable liners of the cylinders (4), have rubber packing rings (5) at the lower end. The cast iron piston (6) is provided with six packing rings and one scraper ring. The connecting rod (7) has a bored channel (8) by which the oil from the big end bearing enters the top end bearing composed of a one piece bronze bush-ing. The upper half of the big end bearing is integral with the stem of the connecting rod.

In the head of the cylinders is to be found the intake valve (9), the starting valve (10), the exhaust valve, the safety valve and the injector. On one side of the cylinder heads is the air receiver tank (11); not only air but also gas, is delivered through the channel (21) on the other side is lo-cated the discharge tank (12) which has a double wall to make possible water cooling. The camshaft (13) is actuated by the crankshaft with the aid of a gear drive. The tappets (14) of the intake valves set the valves in motion with the aid of inter-mediate levers (15) which make it possible to alter the stroke of the valve in order to regulate the gas consumption. The stroke

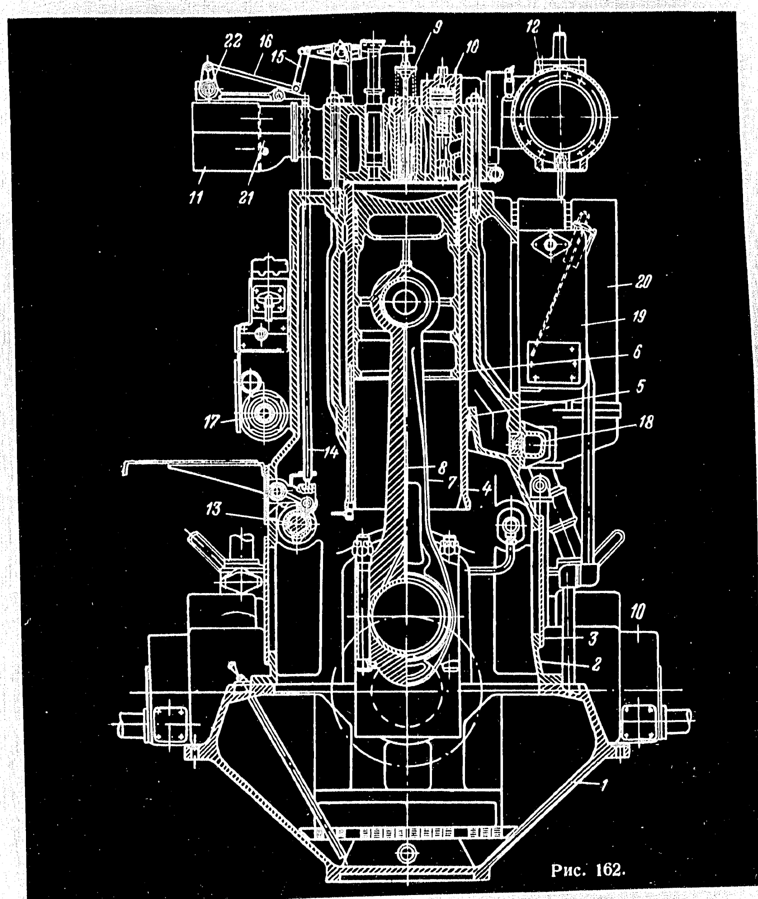

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Figure 162

of the valve is modified by means of lever (16), by turning the small shaft (22). The shaft (17) serves to set in motion the fuel pumps of which there are two for each cylinder (a separate low discharge pump is employed when the engine runs on gas).

A pipe for the supply of cooling water (18), an oil tank (19) and an oil cooler (20) are located on the side of the exhaust valve. On the forward side of the engine there is a two-stage air compressor for the supply of air to the starting receivers, a cooling water pump and a bilge pump, all of these actuated by the crankshaft of the engine.

The engine is reversed by shifting the camshaft with the aid of an air and oil servomotor the construction principle of which is very similar to the design discussed in Section 20 (see Figures 116 and 117). The engine control post is located to the side of and alongside the receiver. Here too the centrifugal governor is located.

The engine is cooled by means of a circulating system. The cooling water supply can be regulated for each individual cylinder. The discharge water temperature permissible where the salt content is low, is up to 70 degrees Centigrade. Where, however, the salt content is higher, the temperature of the water at the discharge end should not exceed 50 degrees Centigrade. Zinc plates for the protection of the cylinder walls against corrosion, are located, around the cylinder jackets.

The bedplate, big and small end bearings are lubricated by means of a circulating system. Issuing from the bearings the oil collects in the bedplte having previously passed through a filter that removes large impure particles. Two gear driven pumps are employed for the purpose of oil circulation. One of these pumps transfers the oil from the bedplate to a special tank from which it is picked up by the other pump and again forced through the filters and oil cooler into the bearings. A manual pump is used for the delivery of oil before the engine is started. Grade 2 motor oil can be used for the lubricant circulation system. The oil temperature in the bedplate of the engine should not exceed 60 degrees Centigrade.

A lubricator serves to lubricate the engine and compressor cylinders, the fuel pump and of the governor. Type T motor oil should be used for this purpose.

As for fuel for the engines under consideration, Diesel oil or solar oil should be used, inasmuch as the viscosity of the fuel at 20 degrees Centigrade should not exceed 20 degrees E. Where the fuel employed is of a higher viscosity, it is absolutely necessary to have it preheated and purified with the aid of a separator.

As the first example of a two stroke non compressor marine Diesel of medium power we shall take the engine produced by the Russkiy Dizel Plant, namely the 4 DR $\frac{24}{38}$, a cross section of which is furnished in Figure 163. It is a four cylinder engine, developing an effective power of 240 horsepower at 375 rpm. The cylinders have a diameter of 24 centimeters, and the piston stroke is 38 centimeters.

The cylinder bank and the crankcase constitute a single

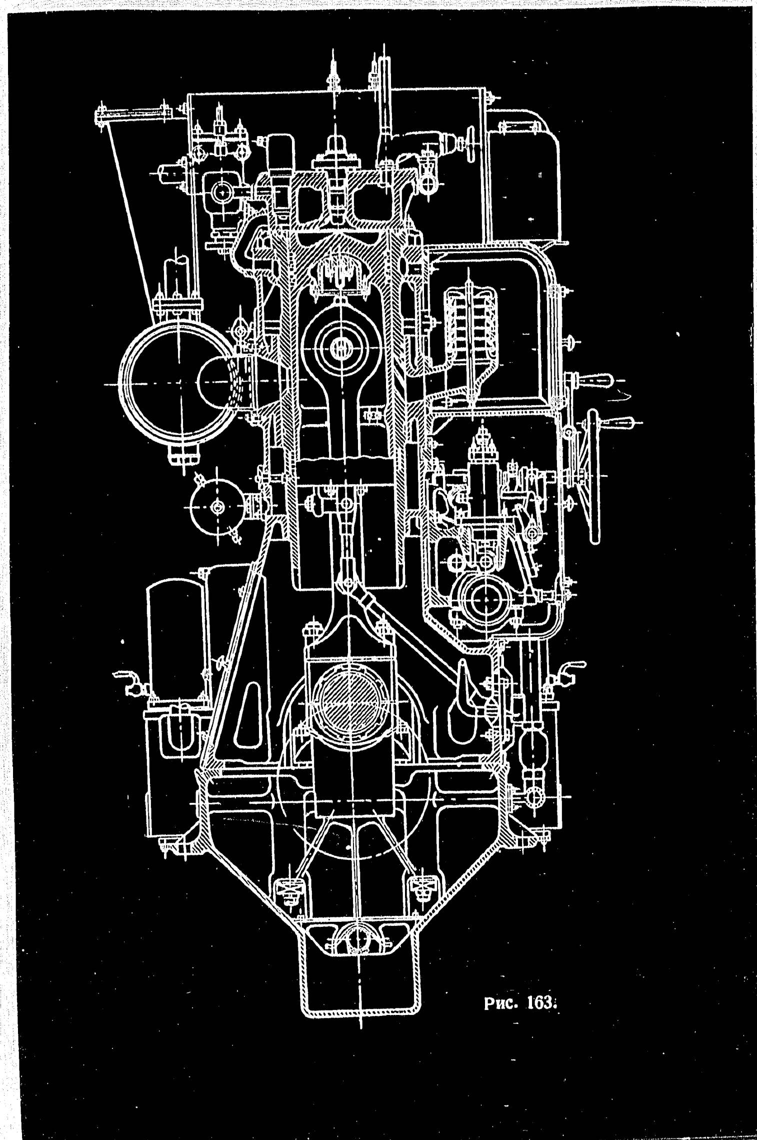

Figure 163

block iron casting. The bedplate is also a solid unit, seamless forged iron casting. The cylinder liners are dismountable, iron cast, with exhaust and scavenging ports. In the cylinder head is to be found the injector, the starting valve, a valve for the separation of the gas used to fill the starting tanks, and the safety valve.

The crankshaft is seamless forged. The connecting rods are of steel, round, bored through and with detachable lower head. The piston is of cast iron, seamless forged with six packing rings and three oil scraper rings.

The lower end of the piston is shaped to enable it to take up the flow of the oil. The piston groove is filled with oil.

The scavenging system is of the type produced by the Russkiy Dizel Plant. The blow-off valves are automatic and lamellated. The scavenging air pressure is 1.18 atmospheres. The gear driven, double acting scavenging pump is actuated by a crank located on the free end of the crankshaft.

The camshaft is set in motion by the crankshaft by means of spur gears. A double set (forward and reverse) of cam plates for the fuel pumps and starting gas distributors, are to be found on the camshaft. Each one of the cylinders has a separate fuel pump. A turn of the plunger regulates the fuel delivery. The rate of speed of the engine can be controlled within a range of from 175 to 375 rpm. A special gear-driven auxiliary pump delivers the fuel to the fuel pumps. A combined and slotted filter is built into the delivery line of this auxiliary pump. Before reaching the injector the fuel also goes through a high pressure slotted filter. The engine employs forced injection under a pressure of 200 atmospheres. The injectors are of the closed type. Solar oil is used for fuel. The rated fuel consumption is 190 grams per effective horsepower hour.

Lubricators are employed for oiling the cylinders. A circulating system serves to lubricate all the other working elements of the engine. The oil pump is gear driven and is mounted in a common housing with the gear pump which serves to supply cooling water. A combined mesh filter and an oil cooler are located in the lubricating system. The pressure of the oil past the filter varies from 2.0 to 2.5 atmospheres. Type T motor oil should be used for lubrication. The rated oil consumption of the circulating system is 2.75 grams per effective horsepower hour.

The engine is cooled with the aid of a circulating system under a delivery manifold pressure of 0.5 atmospheres. The bilge pump which is of the same type as the cooling water pump is also actuated by the engine. Allowing for a temperature differential of 20 degrees Centigrade as between the intake and the discharge water, the water consumption is at the rate of 40 litres per horsepower hour.

The engine is started by the exhaust gases of the two cylinders. The maximum pressure of the starting gas is 30 atmospheres while the minimum pressure under which the engine starts is 15 atmospheres. The starting valves are pneumatically operated. A shift of the camshaft reverses the engine. The reversing gear is manually operated. The control post is located on the side of the camshaft. The starting lever, the reversing flywheel and the hand wheel are also located at the control post.

The SD $\frac{19}{32}$, two cycle, non compressor Diesel produced by The Voronezh Plant imeni Stalin and by the Sormovo Plant, is in wide use on vessels of the river fleet. The SD $\frac{19}{32}$ type engines are adopted as main engines on a rather large number of motorships and suburban launches, and also as auxiliary engines on several motor-ships. Those employed as auxiliaries are generally two cylinder units, developing 70 effective horsepower while the main engines have for the most part four cylinders and develop 140 horsepower. All SD $\frac{19}{32}$ engines operate at 430 rpm. The cylinder diameter of the latter engines is 19 centimeters while the piston stroke is 32 centimeters. Most of the main engines employed are of the non-reversing type and are provided with a reversing and release clutch. There is also a reversing model of the SD $\frac{19}{32}$ engine, with six cylinders, which develops an effective output of 210 horsepower.

A cross section of the SD $\frac{19}{32}$ type engine (reversing model) is furnished in Figure 164. All the cylinder jackets along with the crankcase constitute a single casting. The cast iron dismountable liners are provided with scavenging and exhaust parts. Each of the cylinders has a separate bead which comprises a pre-combustion chamber (since the engine is designed for precombustion spraying) with an injector, a starting valve and a valve for the separation of the gas.

The piston end is convex and has five packing rings and two

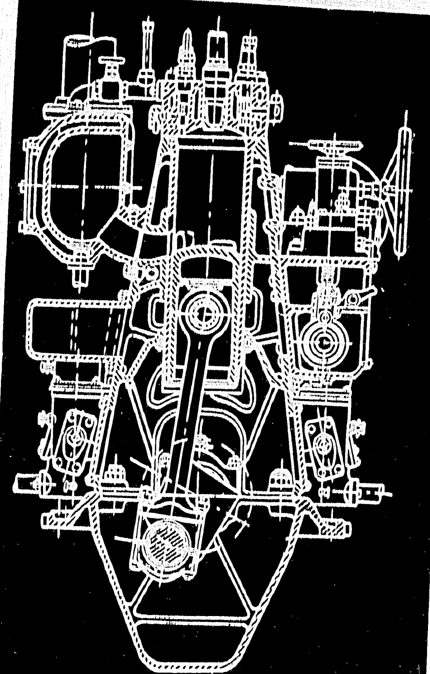
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Figure 164

oil scraper rings. The connecting rod is round with a groove for the delivery of the lubricating oil to the top end bearing. The lower end bearing is removable. The rotary scavenging pump (see Figures 132 and 133) is mounted on the flywheel casing and is actuated by the crankshaft with the aid of spur gears. The scavenging air pressure is 1.13 to 1.15 atmospheres.

The camshaft of the non-reversible engines is mounted perpendicular to the axis of the crankshaft and is driven by the latter through the intermediary of helical gears. The cam plates of the fuel pumps and those of the starting distributor are located on the camshaft. Moreover, the shaft is located on the opposite side of the flywheel. In the case of the reversing engines, the camshaft is mounted parallel to the crankshaft and is driven by the latter with the aid of spur gears. A double set of cam plates of the fuel pump is to be found on the camshaft. In addition, a double set of cam plates of the starting distributor is mounted on a special small shaft which is coupled to the camshaft.

The fuel pumps with needle valve controls (Section 17) are mounted on the control post. On units which serve as main engines, the rate of speed can be varied from 280 to 340 rpm. The centrifugal governors of engines designed to be powered by dynamos make possible the maintenance of a uniform rate of speed, with an allowance of 5 percent. The fuel injection pressure is 100 to 120 atmospheres. The injectors employed are of the closed type. The engine can be fed with M-3 motor oil. The rated fuel consumption is 195 grams per horsepower hour, with an allowance of 10 percent.

The liners are spray lubricated while the other working parts are lubricated by a circulating system. The oil pump is gear driven and is actuated by the crankshaft with the aid of gear wheels. A mesh filter and an oil cooler are provided for the oil system. The oil pressure past the filter is 1.7 to 2 atmospheres. Type M motor oil is recommended for lubrication. The rated oil consumption for the latter is 9 grams per horsepower-hour.

The engine is equipped with a circulating system for cooling. The cooling water is delivered under a pressure of 0.5 atmospheres with the aid of a gear driven pump. The cooling water consumption is 20 litres per horsepower hour, the differential between the temperatures of the intake and outlet water being 40 degrees Centigrade. The engine has a bilge pump of the same type as the cooling water pump (that is, only for main engines).

The engine is started with the aid of the exhaust gases the pressure of which is up to 30 atmospheres. Minimum engine starting gas pressure is 15 atmospheres. Igniters are used to facilitate starting a cold engine. The engine is reversed by altering the position of the cam plates of the fuel pumps and those of the starting gas distributor.

The incomparably high dependability in service of the SD $\frac{19}{32}$ type engines, which in this respect are superior to many imported engines of similar design, should be noted here. The shortcoming of the SD $\frac{19}{32}$ consists in the tendency to accumulate carbon deposits in the exhaust pipes owing to imperfect combustion. The accumulated carbon is apt to ignite periodically and the exhaust pipes may grow hot to a point at which they constitute a fire hazard. For this reason special care must be taken to maintain the fuel system in a state of good repair, not permitting imperfect fuel combustion. Even considering the relatively high rate of speed, the weight of the SD $\frac{19}{32}$ Diesel is still excessive, namely, 30 kilograms per effective horsepower.

In addition to the SD $\frac{19}{32}$ type engine, one also finds on motorships and suburban launches ("river trolleys") engines of foreign construction, such as Climax, Modaag-Krupp, and other engines. The design of the latter engines approximates that of the engines we have described.

SECTION 31. THE DESIGN OF HIGH SPEED NON-COMPRESSOR DIESELS

All slow speed marine Diesels are of heavy construction. They are also characterized by large overall dimensions. The great weight lessens the effective carrying capacity of the ship, and besides the size of the engine room is increased. The heavy weight of slow speed engines aboard ships intended for shallow rivers, gives rise to serious problems, including at times the inability of providing a short draught.

High speed Diesels do not suffer from the same drawback, while in the case of low speed Diesels the weight per horsepower (specific weight) ranges from 25 to 85 kilograms, the specific weight of high speed Diesels is only 6 to 15 kilograms. The overall dimensions are also several times smaller resulting in the reduction of engine room size.

The design of high speed Diesels is generally such that they

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do not require direct surveillance while in service and the engine can be controlled from the pilot house. This makes possible an appreciable reduction in the engine crew.

To achieve an identical index of technical and cost values, a ship powered by a high speed Diesel is able to effect the following economies as against one powered by a low speed Diesel: A reduction in the hull dimensions of 1.6 times, a displacement 2.1 times smaller, construction cost 2.6 to 2.9 times lower and operating cost 1.5 times lower. [See article by Engineer S. D. Vozdvizhenskiy and Engineer M. N. Brezhnev "The Superiority of Motor Ships with High Speed Engines" which appeared in the periodical Rechnoy Transport (River Transport), No 8, 1947.]

The weight of the engine plant of a power driven barge with a load capacity of 2,000 tons and a 600 horse power engine output was 53 tons where 6 ChR $\frac{29}{43}$ engines were employed, whereas with V-2 engines aboard that barge, the plant weighed only 15 tons. Moreover, high speed engines require a negligible cubic space for the engine room.

The design of high speed Diesels has a number of distinct features not encountered on slow speed Diesels. First of all, it should be noted that high speed Diesels are for the most part four stroke engines since on account of the higher piston speed of the two cycle engine, i.e. 7 to 11 meters per second, it is difficult to provide for the proper removal of the combustion products from the cylinder and for the supply of fresh air to the latter.

In order to render easier the exhausting of the products of combustion in a four stroke engine and to improve the supply of fresh air to the cylinders, it is necessary to have intake and exhaust valves of the highest possible longitudinal section. Very frequently high speed engines have two intake and two exhaust valves.

The rate of speed of the high speed Diesels varies from 600 to 3000 rpm. The necessity of reducing the inertia under these circumstances, prompts the maximum possible reduction of the weight of the working parts of the engine. Hence, light aluminum alloys are frequently used as stock for the pistons, while steel alloys, and the like are employed for the fabrication of the connecting rods and crankshafts, owing to their greater ability to withstand strains, etc.

High speed engines installed on river craft have a relatively limited output (generally up to 300 effective horsepower) and are nearly always designed as non reversible. The high rate of speed, as a rule, makes it impossible to couple the engine shaft directly to the propeller shaft. For this reason high speed engines should be provided not only with reversing-releasing clutches but also with a gear drive (reduction gear) by means of which they are coupled with the propeller shaft, the rate of speed of which is several times lower. Very frequently the reversing-releasing clutch and the reduction gear are combined into a single assembly known as the reverse-reduction gear.

High speed engines are always completely enclosed and have all the systems (lubricating, cooling, etc.) of the fully automatic type. For this reason they do not require constant supervision by the engineer crew and can be controlled from the pilot house. Hence, all controls should be extended to the pilot house and all the measuring instruments used to indicate the performance of the engine (number of revolutions, oil pressure, etc.) should be located inside of it.

The earliest engine which in point of design approximated high speed engines most closely and which was adopted for ships of the river fleet was a non compressor Diesel developing 75 horsepower at 850 rpm; it was originally built as a tractor Diesel by the Chelyabinskiy Tractor Plant and was known as the M-17. The M-17 is a four stroke four cylinder engine with a cylinder diameter of 15.5 centimeters and a piston stroke of 20.5 centimeters. Since the average speed of the pistons of this engine is 5.8 meters per second, it is not a high speed engine in the strict sense (since according to GOST 4393-48, the average piston speed for the latter type is upward of 6.5 meters per second).

A cross section of the M-17 engine is shown in Figure 165. The bank of cylinders and the crankcase (1) compose a single casting into which are introduced the liners (2). The pistons (3) are each provided with five packing rings and two oil scrapers. The piston pin is held by the top end bearing of the connecting rod (6).

The lower end bearing of the connecting rod holds the pin of the crankshaft (7) which has counterweights (8).

The head of each cylinder comprises an intake and exhaust valve. The camshaft (4) is actuated by the crankshaft with the

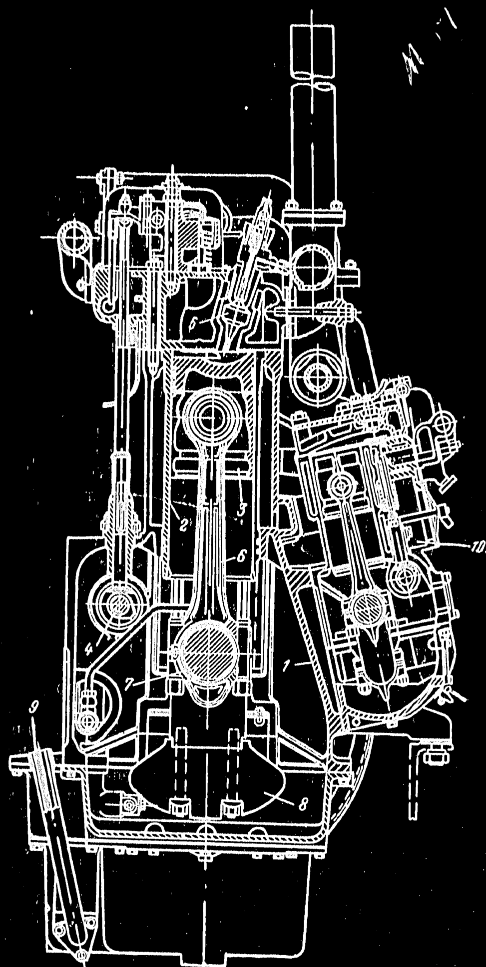

Рис. 165.

Figure 165

aid of geared wheels. An all-speed centrifugal governor is located at the end of the camshaft. The lower end of the crankcase terminates in a sump where the gear driven oil pump is located.

The precombustion chamber (5) is located in the cylinder head. Into the precombustion chamber enters a closed injector into which the fuel (solar or Diesel oil) is transferred with the aid of a fuel pump of the slide valve type under a pressure of 110 to 115 atmospheres. Copper and asbestos packing is inserted between the cylinder head and its flange. A graduated scale (9) in the sump serves to indicate the oil level.

The engine is started with the aid of a special gasoline starting engine (10) coupled to the crankshaft by means of a gear drive and a release clutch. The starting engine, a two cylinder, four stroke unit, develops an effective power of 18 horsepower at 2,200 rpm.

In respect of its design the M-17 represents a transitional stage towards the authentic high speed engine and here lies the reason why in operation it does not give rise to certain typical problems that we associate with the operation of high speed Diesels, such as those that beset the functioning of the oil feed system.

The Herkules engine which has been adopted for some of the new vessels of our river fleet, is a typical example of a modern high speed Diesel. The Herkules engine is a six cylinder, four stroke, non compressor Diesel with a swirl chamber which develops an effective output of 150 horsepower, at 2,600 rpm. The cylinder diameter is 107.95 millimeters (4-1/4") and the piston stroke is

120.65 millimeters (4-3/4"). A characteristic feature of the Kerkules engine is the supercharger, that is, the feeding of the air into the cylinders during aspiration, under a boosted pressure (1.56 atmospheres), in order to augment the output (for further details see next section).

Figure 166 shows the cross section of a Herkules engine while a longitudinal section is furnished in Figure 167. All cylinder jackets are placed in a common bank including also the crankcase, and they are coupled with the bedplate (2) axially through the crankshaft. The bank and the bedplate are both iron castings. All the six cylinders have a common head. It is an iron alloy casting, secured to the cylinder bank with the aid of 45 pins. The cylinder liners are not in contact with the water since the latter washes the internal part of the cylinder bank. At the upper end of the cylinder bank are located the swirl chambers (5) into which the injectors (7) are introduced. The piston is an aluminum alloy casting and is provided with three packing rings and two oil scraper rings. The piston pin (6) is of the floating type. The connecting rod has a double-T profile. The crankshaft is seamless welded and mounted on brackets with lead bronze bushings. The surface of the crankpins is case hardened by a high frequency current, and is thereby made more wear resistant. On the after side of the shaft is mounted a flywheel (9) with a spur gear (10) with the aid of which it engages with the drive of the electric starter. At the forward end of the shaft (14) is the muffler (8) which serves to absorb the rotary vibrations of the shaft.

The rotary pump (11) for supercharging is actuated by the engine shaft via wheels (12) and (14) and by the link chain (13). The camshaft is connected with the engine shaft by means of a gear wheel. The cam plates of the intake and exhaust valves are forged to form a single unit with the camshaft.

The engine is provided with closed injectors and slide valve pumps. A centrifugal all-speed governor is coupled to the pump.

The oil injection pressure is 115 atmospheres. Either Diesel or solar oil may be employed for fuel. The rated oil consumption is 240 grams per horsepower hour.

The Herkules engine is lubricated by means of a circulating system. Two gear driven oil pumps (in addition a separate, gear driven pump delivers the fuel to the reverse-reduction gear) are provided for oil circulation. The oil is purified by a twin mesh and reduction filter which is also twin. A lamellated oil cooler serves to cool the air. On leaving the pump the oil pressure is 3.5 atmospheres.

The engine has a sealed cooling system which has been described in Section 27. The water pressure inside the system is 0.72 atmospheres. The pressure of the sea water is 0.45 atmospheres. The consumption of overboard cooling water is 68 litres per effective horsepower-hour.

The engine is equipped with a reverse-reduction gear, with a reduction ratio of 2.04 to 1. A direct current, 24 volt, 250

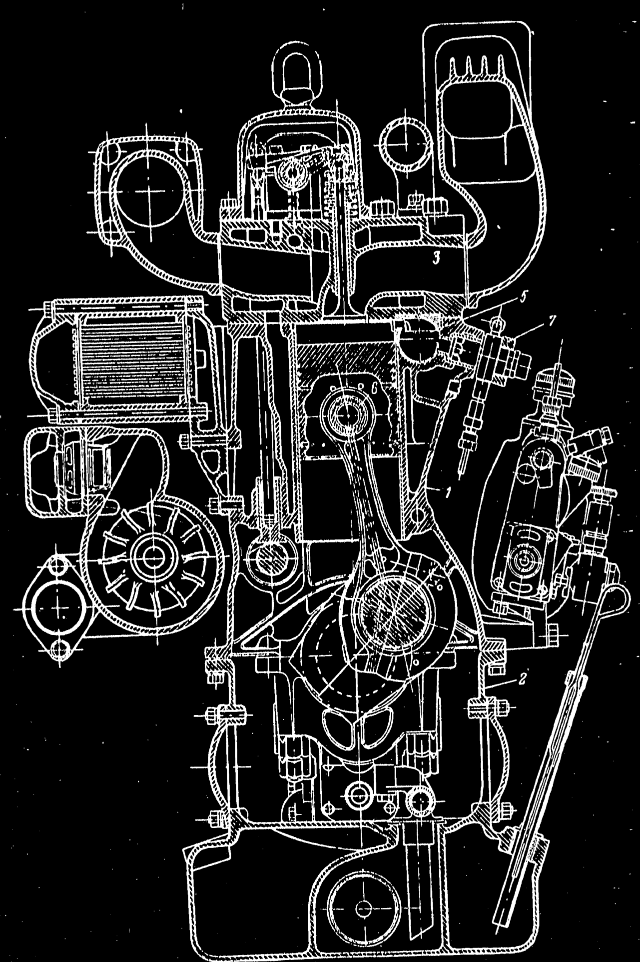

Рис. 166.

Figure 166

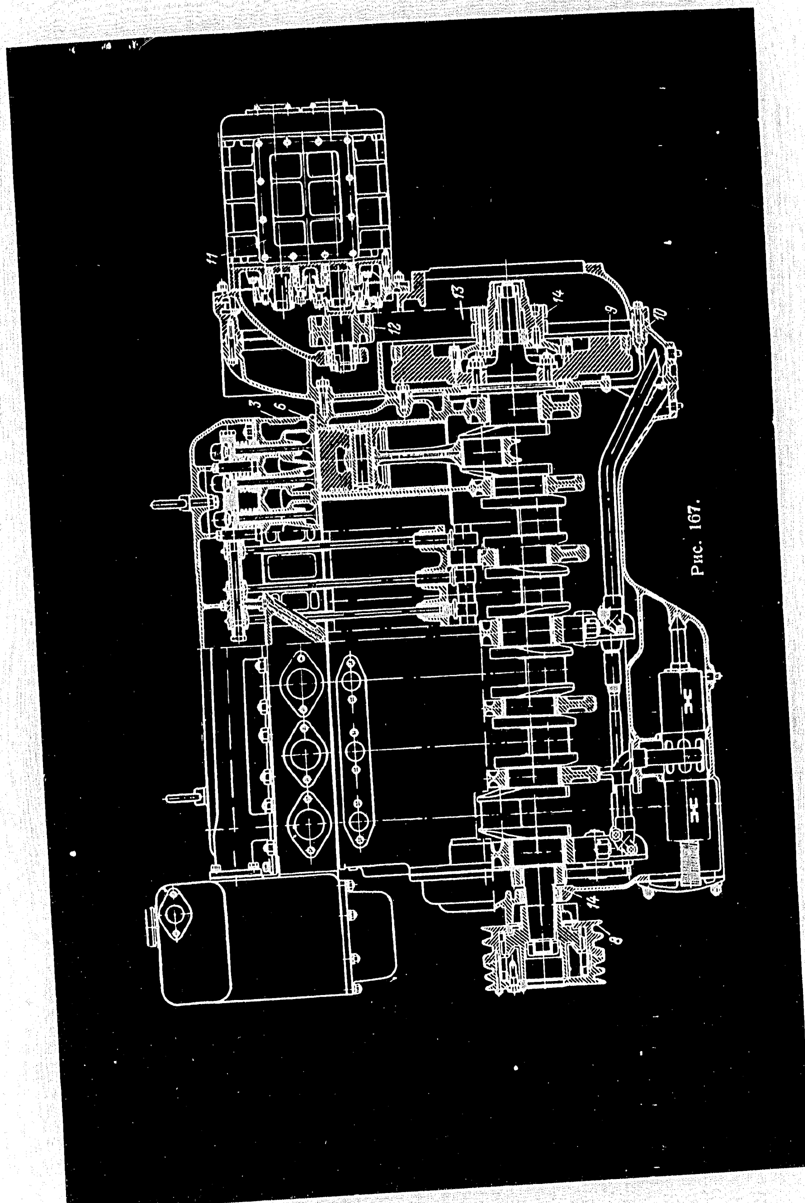

Figure 167

watt electric generator is driven by the engine.

An electric starter powered by a storage battery is employed to start the engine. A burner, ignited by electric sparks serving also to warm the air aspirated into the engine, is provided. This device facilitates starting. The fuel most suited for this burner is a mixture of benzene and kerosene rather than pure benzene.

The Herkules engine has the advantage of a high degree of compactness and low weight which comes only to 7.86 kilograms per effective horsepower. River boats use Herkules engines which develop an output of 300 effective horsepower, at 2,000 rpm.

In the years to come high speed Diesels of Soviet design will be adopted on a rather wide scale for river boats. The V-2 engines must be given priority ahead of any other type.

V-2 engines are produced with six and twelve cylinders whose respective output is 150 and 300 horsepower. The twelve cylinger V-2 engine cylinders are mounted in two banks forming the letter V. The V-2 engine rate of speed is 1500 rpm. The cylinder diameter is 150 millimeters and the piston stroke measures 180 millimeters.

Figure 168 shows a cross section of the twelve cylinder V-2 engine. The two banks of cylinders form a 60 degree angle. The cylinders are provided with cast iron, water cooled liners.

Each of the cylinder banks has a common aluminum alloy head. Each cylinder also comprises two intake and two exhaust valves, an injector and a starting valve. The injector is located at the center and delivers seven streams of oil. It forms a tapered, circular nozzle, with an angle of 140 degrees at the vertex. The bottom of the piston is dished with upturned edges. The pistons are aluminum castings, provided with four packing rings and two oil scrapers. The piston pin is of the floating type. The crankshaft is hollowed out. The connecting rods of one cylinder bank are connected to the shaft while those of the other bank are connected, that is, they are joined to the connecting rods of the first cylinder bank by means of ball and socket joints. The bearings are lined with plumbous bronze to withstand friction. Closed type injectors are employed and the fuel pumps are of the slide valve type. The 12 plunger fuel pump is located between the cylinders. The all-speed governor is also located here. The rated fuel consumption is (either Diesel or solar oil) 185 grams per horsepower hour.

The engine is lubricated by circulation and has a sealed cooling system with a thermostat and centrifugal pumps. A 24 volt, 1 kilowatt dynamo is driven by the engine. A 12 horsepower electric starter or compressed air is used to start the engine.

For the aluminum alloy housing, the weight of the twelve cylinder engine is only 2.5 kilograms per effective horsepower. Where the housing is an iron casting, the weight of the six cylinder engine comes to 6.6 kilograms per horse power. As shown by the index figure for weight and cost, the Soviet built engines are superior to the American engines of the Herkules type.

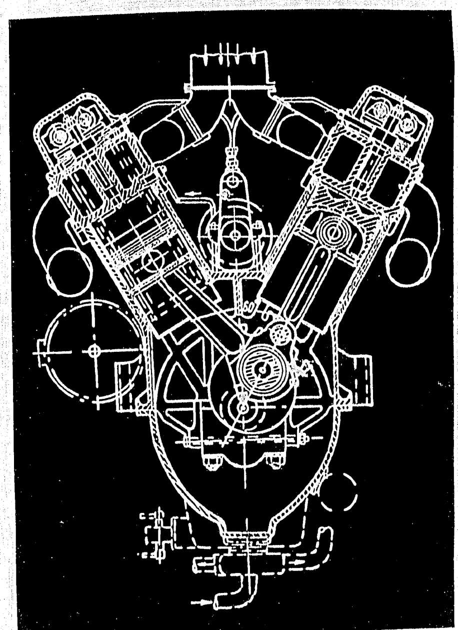

Figure 168

The engine is designed with a reversing reduction gear. The reduction ratio may be either 2:1 or 3:1.

The 3D-6 high speed, non compressor Diesel with pump injection, built in the Soviet Union is of the same basic dimensions. The 3D-6 is a six cylinder engine, developing 150 horsepower, at 1,500 rpm.

Figure 169 shows a cross section of this engine. The cylinders are arranged in vertical order and in a single row. The engine housing and the bedplate constitute a single aluminum casting. The cylinder liners are of cast iron and dismountable. The pistons are of aluminum alloy and are dished at the lower end, with upturned edges. They are provided with three packing rings and two oil scrapers.

The connecting rod is forged steel. The lower end bearings have lead and bronze bushings. The crankshaft rests on seven frame bearings, similar equipped with lead and bronze bushings.

All cylinders have a common aluminum alloy head. There are two intake and two exhaust valves per cylinder, and they are actuated by two camshafts (1) secured to the cylinder head. There are also starting valves (2) actuated by air.

A slide-valve type fuel pump with an all-speed governor is located on the left side of the engine. The pump is driven by the air distributor shaft of the starting valves. Over it is to be found a fuel filter. The receiving manifold (4) is also located on this side. A special auxiliary pump serves to deliver the fuel to the fuel pump. This special pump overcomes the re-

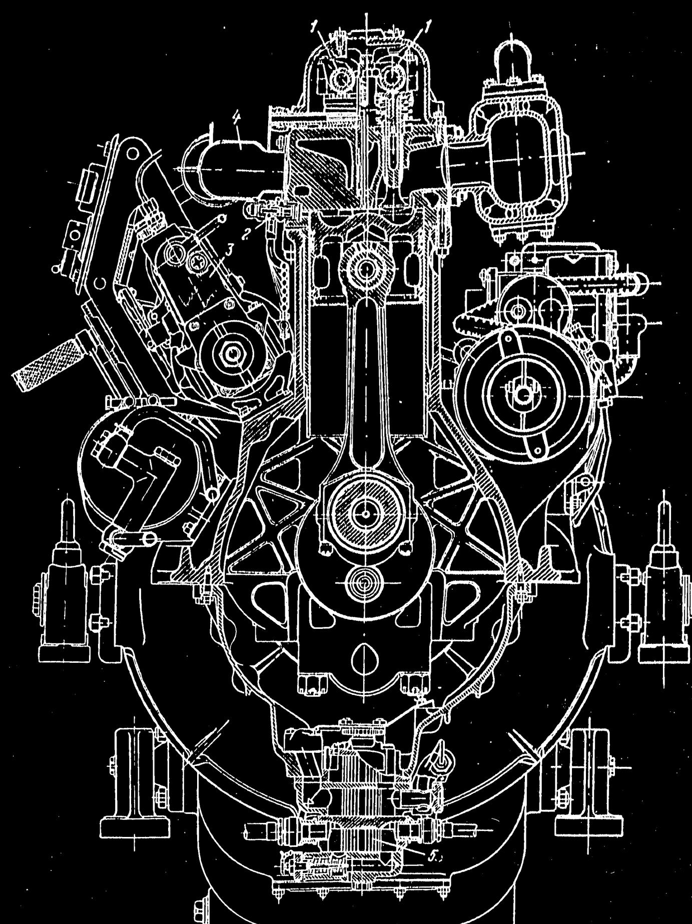

Рис. 169.

Figure 169

sistance of the felt filter which is about 0.5 to 0.7 kilograms per centimeter square. Diesel oil should be used for fuel.

The rated consumption of fuel is 190 grams per horsepower hour. The engine is provided with closed injectors. The construction of these injectors has already been described above (see Figure 90).

A double action, gear driven pump of the fuel oil system (5) is located on the crankcase cowling. A slotted wire mesh filter is available for the purification of the oil, while an oil cooler which makes use of sea water is used for cooling. The only oil to be used for lubrication is the MK aviation oil.

The engine is provided with a closed cooling system. The centrifugal pump sends the purified water circulating in the inner system. The hot water which issues from the engine is collected in a small tank from which it runs to the cooler which is cooled by the sea water and from there it returns to the pump. The sea water passes through the sea cock (Kingston), through the filter, and is then delivered by the pump into the water cooler and into the oil cooler. Thereafter the water cools the discharge manifold and drains out to sea. The reversing-reduction gear is secured to the casing of the flywheel. For the forward run it has a reduction ratio 3.07:1 and for the after run the reduction ratio is 2.96:1. The dynamo and the electric starter are located on the right side of the engine. The engine can be started either with the aid of the electric starter or by compressed air.

The overall weight of the engine, that is, taking into account all the accessory mechanisms is 1,200 kilograms. Hence, the specific weight is 8 kilograms per horsepower. It is expected that the 3D-6 engines will, in the near future, receive wide acceptance on all types of river boats.